# 8 Multiplayer Serious Games

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**Abstract**

This chapter covers the topic of multiplayer serious games. Multiplayer games are discussed in terms of game types and forms, genres and techniques, as well as their impact on the use of multiplayer games. Based on that, this chapter will show how different types of multiplayer genres and techniques can be used for various serious game purposes. This chapter further provides an introduction to the topic of collaborative learning and collaborative multiplayer games—and their use for game-based collaborative learning. We discuss how collaborative learning concepts are inherently used by some massive multiplayer online games, and how those concepts can be used more thoroughly by using the multiplayer paradigm for game-based collaborative learning. Further, it is shown how various multiplayer design aspects like number of players, persistency, matchmaking, interaction, or social aspects need to be considered in the design phase of a multiplayer game.

## 8.1 Introduction

A game is called a *multiplayer game* when two or more players play it together—either against each other, together in teams against other teams, or completely cooperatively against the computer.

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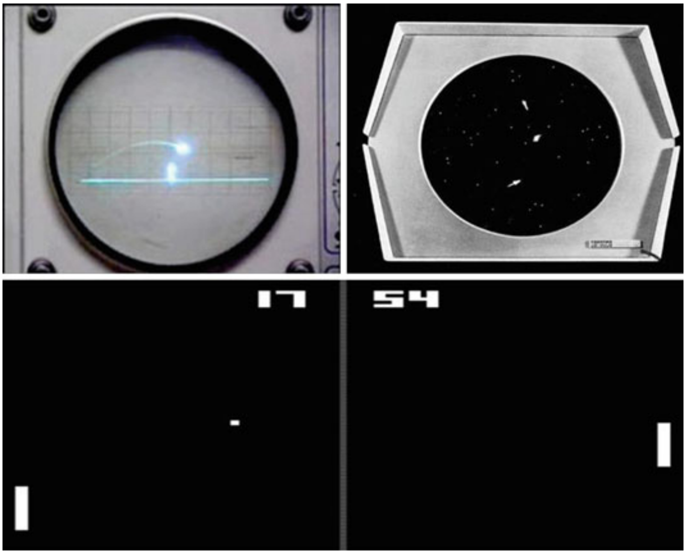


**Fig. 8.1** *Upper left Tennis for Two* (1958) played on an oscilloscope. *Upper right Space Invaders* (1961). *Bottom Pong* (1972)

The concept of multiplayer games is not an invention of digital games. Rather, is as old as mankind itself. Children play with their parents and start playing with other children at a very young age although the rules defining the game are often rather lax. Even among animals—especially those living in herds or packs (e.g., wolves or lions)—playing can be observed especially among young animals, which is often considered a form of training for their later lives.

So, what makes people want to play with each other? Obviously, there are various components which (can) improve a game with other players compared to playing alone. One of them is the *social component*, as playing multiplayer games comprises interaction with other people (e.g., debating about team strategies, praising each other, etc.). On top of this, there is the *competitive element* that makes playing with other human players challenging.

When looking at the history of digital games, *Tennis for Two* (1958) or *Spacewar* (1961) were two of the early digital games—both are multiplayer games. They are shown in Fig. 8.1.

In the early years of digital gaming with limited hardware resources, AI players were hardly an option. Hence, most games were designed as player versus player games. In later years, with upcoming arcade game consoles, more and more single-player games were developed with multiplayer variants being mostly played in split-screen or shared-screen mode, like *Pong* (1972), see Fig. 8.1.

With the arrival of the Internet, game technology made a big step towards more multiplayer-centered games. Network technology via LAN or wide-area networks enabled game modes where many players could be part of one game, with each player having his/her own screen. The split-screen or shared-screen mode was no longer necessary. Popular multiplayer genres developed, from First-Person-Shooter (FPS) games over multiplayer Real-Time-Strategy (RTS) games, or round-based strategy games towards Massive Multiplayer Online (MMO) games. The first popular MMO games were MMO role-playing games (MMORPGs), with popular representatives like *World of Warcraft* (WoW) or *EverQuest*. Other MMO games were more focused on an open online world (e.g., *SecondLife*) or made use of social components, like the recent generation of Facebook games (e.g., *Farmville*). Most recently, Massive Online Battle Arenas (MOBAs) (e.g., *League of Legends, DotA*) have emerged as the latest MMO genre.

The increasing role of multiplayer games in today's games market, as shown by the success of MOBAs like *League of Legends* or *DotA2*, prove the fascination of multiplayer games. In 2014, *League of Legends* created revenues of $946 million USD (Statista 2014) and had more than 67 million active players per month (Statista 2014). On average, players in the US spent 107 min/day playing online games in 2013 (97 min in Europe) (Statista 2013). Apart from MOBAs, there are FPS (*Modern Warfare*), RTS games (*StarCraft, World of Tanks*), roleplay games (*WoW*), or other emerging genres like card-based games (*Hearthstone*).

Multiplayer games offer—by playing with or against other human players—competition (Mitchell and Savill-Smith 2004; Vorderer et al. 2003), cooperation, and other forms of social interaction (Manninen 2003), which might be the main reason for their popularity (see Sect. 8.2 for more details on various forms of multiplayer serious games). This social component is one major argument for using multiplayer concepts and technology for serious games (Ducheneaut and Moore 2004). Multiplayer technology can also be used very well in serious game application areas today; in fact, many of the above examples have been used for multiplayer serious game applications. Multiplayer serious games can offer the inclusion of a social component on top of the serious games principle and hence engage players on a social level. Moreover, principles from the collaborative learning paradigm can be used in multiplayer serious game scenarios. This enables players to learn in groups, thus making use of established group learning principles and mechanisms (see Sect. 8.3).

There is another aspect in games that appears to be very present in multiplayer games, especially MMORPGs. Players tend to spend considerable time learning a game, often even without playing it. It is a frequently observed phenomenon that players visit wikis, forums, or other websites dedicated to the MMO they like to improve their gameplay with, or learn something new about, the game (Voulgari and Komis 2008; Gee 2003; Yee 2005; Dickey 2007). There are theoretical results as to why players spend so much time learning a game, and how this motivation can be used in serious games (Gee 2003; Garris et al. 2002; Prensky 2006). This inherent motivation might be one more driver for the use of multiplayer serious games.

The concept of competition might also be a main motivation for multiplayer serious games. When players can learn from a game, this effect might be improved when players play the game against a human opponent, because competition is more real when there is a real (human) opponent. It has been shown that one learns best when the challenge is optimal (Sweetser and Wyeth 2005). Hence, suitable opponents are required to optimize the learning process. However, AI-based opponents are often limited—both in their skills and in their strategic variability and adaptability. Whereas players can train reflexes in shooter games, they can become more elaborated when playing against human opponents as those intelligent opponents tend to develop new strategies and change their behavior. For the same reason, human opponents can be better opponents in strategy games. Generally, human opponents are considered to be more challenging whenever an AI-based opponent is pushed to its limits. However, the question of finding an opponent best suited for a given player is not trivial; this will be elaborated below.

Learning theories (behaviorism, cognitivism, constructivism) highlight the important role of social interaction in different ways, but all agree on the supportive effect such *peer education* has for learning (Piaget 2003; Doise et al. 1975; Vygotsky 1997; Bandura 2002). More recently, George Siemens received attention in the field of technology-enhanced learning with his theory of connectivism, which focuses more on *know-where* instead of *know-what* (Siemens 2005). With a focus on serious games, the question in terms of social interconnection is not only to find team members or opponents of a similar competitive strength, but also with capabilities—like prior knowledge and personality traits—that lead to maximum learning progress for all players. Some aspects of this *learning group formation problem* and their potential of peer education are nicely described and analyzed by (Damon 1984). Initial algorithmic solutions are compared by (Konert et al. 2014). A literature review of relevant matching criteria for learning group formation can be found in (Konert 2014a). To mention one example, (Paredes et al. 2010) found out that homogeneous groups perform better on specific tasks, whereas heterogeneous groups perform better on broader tasks. These and other aspects have to be taken into consideration when designing team matching and group tasks in games.

Apart from finding a good match for players and opponents, other major challenges for multiplayer games comprise the heterogeneity of players and learners in general. As players have different preferences and affectations for games, genres, and ways of playing, it is almost impossible to create games that are equally appealing to all players. Also, in terms of learning, there are differences between the players (e.g., learning style, state of knowledge, etc.) that need to be considered. This constitutes a major challenge of using multiplayer serious games and leads to the research field of adaptation and adaptivity. Moreover, in collaborative learning scenarios, the role of the instructor needs to be considered, as the instructor plays a vital role the learning process. This special role needs to be considered both during game design and at runtime (see Sect. 8.3).

## 8.2 Forms of Multiplayer Serious Gaming

As explained above, multiplayer serious games offer a multitude of application fields due to multiplayer benefits that can be utilized in various forms. In this section, the different types and forms will be elaborated. As a first step, different types of multiplayer games will be described from a technical perspective, explaining technical possibilities and limitations and their implications.

After that, game types are discussed in relation to the type of player interaction, i.e., in terms of competition, cooperation, and collaboration. Implications for the games will be discussed and fields of applications derived.

### 8.2.1 Multiplayer Types and Techniques

Generally, there are different types of multiplayer techniques that impact the way players use a screen.

Players can play a multiplayer game using *one computer,* subsequently using one screen. Traditional multiplayer games—from the time when networking did not exist—had to rely on this technique. When only one screen is available, it needs to be decided in which way information is presented to the players. The method of sharing strongly depends on the game genre itself. If players play consecutively, there is no need to share screen space; players just take turns at the same computer. All players are usually around the screen where a player takes his/her turn. Therefore, from a gameplay perspective, it is very difficult to display sensitive/private information to a specific player (e.g., tactical advice), as the other players might also get that information.

If, on the other hand, players play simultaneously on one machine, the available screen space needs to be shared or divided among the players. Again, depending on the genre of the game, this can be done in various ways.

The most traditional way is the so-called *split screen*. This technique is used to split the available screen in (usually two or four) equal parts, depending on the number of players. As the screen space is limited, it appears to be not advisable to split the screen in more than four parts, as this would result in too small pieces for each player. Hence, this limits the number of players. An example for the split-screen approach is shown in Fig. 8.2.

A different way for displaying the screen for multiple players is a *shared screen*. Here, all the players are displayed on one screen at the same time. Although this is a very simple concept, it comprises some very important limitations regarding the game design. As there is only one screen for all players, the game design needs to reflect all player movements. The simplest idea is to restrict the level itself to a certain size so that it can be displayed completely in one screen. The players cannot leave the screen. If, however, the level needs to be larger, strategies need to be used

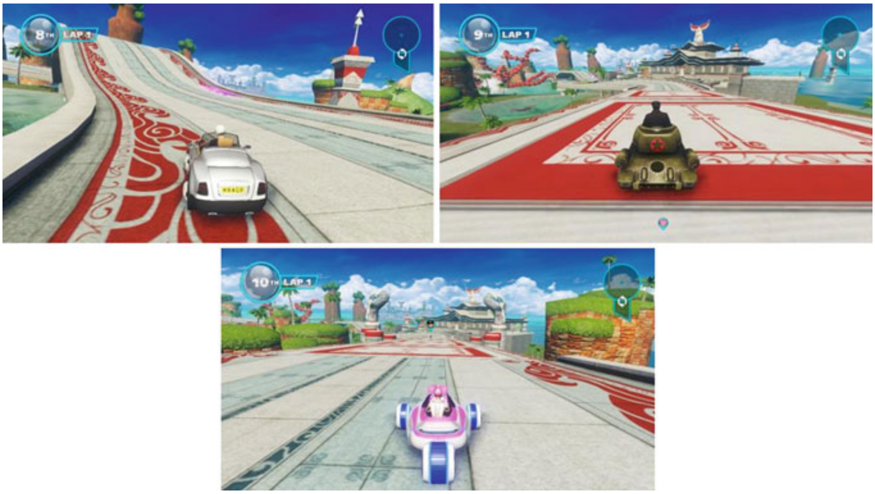

**Fig. 8.2** Splitscreen for three players in the game *Sonic & All-Stars Racing Transformed* (PC version; screenshot created by the authors)

**Fig. 8.3** Shared screen in the video game *Castle Crashers* (PC version) (screenshot created by the authors); all four players share one screen

to prevent players from leaving the screen. This can be done either by forbidding a movement towards a screen edge when other players are too far away (e.g., *Trine, Spelunky*), or by zooming out when players move in different directions (e.g., Xbox game *Teenage Mutant Ninja Turtles*, see Fig. 8.3). This, however, is limited by a maximum zoom distance—which again is defined by a minimum size of game objects on the screen.

Multiplayer types are defined by the number of players in a game and how the players access the game. In terms of presentation, players might use one device per player or share a device via split screen, shared screen, or by taking turns. For networked multiplayer games, network issues like latency, jitter, or packet loss are more or less relevant depending on the game genre.

With the arrival of network technology, and especially the Internet, a new multiplayer paradigm emerged. As it is now possible to interconnect computers, players can now participate with more than one computer in a game, with each player playing on one computer and thus on one screen. Although this solves the problem of how to best use the screen, it imposes new challenges.

The core issue with networked games is latency, which is mainly a problem with players using the Internet rather than players in a local area network. The topic of latency, also with a focus on games, is a major research area in the field of computer science. As there is a lot of literature on this problem (Armitage et al. 2006), it will not be elaborated further here.

Also, in terms of game design, Armitage et al. (2006) provides an exhaustive overview on how to minimize the effect of latency by lossless (Welch 1984) and delta compression, player and opponent prediction, time manipulation, interest management, or update aggregation.

When designing a multiplayer serious game, it should be considered from the beginning how much the gameplay relies on real-time execution. Depending on the game genre, there are different requirements for latency. For a realtime strategy game (RTS) or a first person shooter (FPS), for example, low latency is very important. For MMORPGs, the tolerance for a higher latency is bigger. And for round-based games, even higher latency is tolerable.

In many European schools, for example, Internet access is still mediocre or bad. This results in major latency issues, especially when 20+ computers share a narrow-band Internet connection.

### 8.2.2 Multiplayer Game Genres

As shown in the previous section, the game genre has a major impact on multiplayer game design. Clearly, different game genres are appropriate for different application areas. Whereas FPS-like games might be applicable to train a player's reaction, interactive simulations might be the best choice when the goal of the game is to teach about a complex process. How can different multiplayer genres be used for serious purposes? This is mainly motivated from successful serious game examples:

*First Person Shooters* (FPS) are games relying heavily not only on quick reaction times and good reflexes, but also on knowledge about the level and on strategic thinking, especially in coordination within the team. Hence, FPS


**Fig. 8.4** Screenshot of the serious first person shooter game *Re-Mission* (Kato et al. 2008)

mechanics can be used to train motor skills like reflexes, and to train aspects of teamwork. However, there are also examples of FPS mechanics used for educational games (e.g., *MathShooter, DimensionM, WordDomination*) or for informing and motivational shooters (e.g., *Re-Mission*, see Fig. 8.4).

Multiplayer genres can be classified by aspects like the number of players, the dependency on technical aspects like latency, the importance of controls and input devices, and the importance of consistency of the game state or the game world. Other aspects refer to the game speed, i.e., whether the game is played in real-time, in a turn-based fashion or at varying speed. Resulting genres cover strategy games (chess), real-time strategy games (*Star Craft*), 4X games (*Civilization*), first-person shooters (*quake*), simulation games (*crusader kings*), asynchronous browser games (*Travian*), multiplayer online games (*World of Warcraft*), virtual worlds (*Second Life*), and multiplayer online battle arenas (*League of Legends*). Adventure games or interactive movies are one significant exception, as they are mainly designed for single-player use.

*Strategy games* are usually based on tactical and strategic thinking, which is related to problem solving. As many strategy games use *war* as a narrative setting, they often are set in a historical context. This makes them well suited for teaching history-related content, if the latter is well integrated into the game. Further, they can be used to train teamwork, especially on a more resource-based foundation, with players using different resources in one team and hence becoming dependent on each other. There are many examples of games that fall under the 4X category, like *Sid Meier's Civilization*.

*Real-time strategy (RTS) games* are a special class of strategy games in which the game is played in real-time as opposed to turn-based. As this genre is among the most popular ones, it is discussed separately. Similar to strategy games, RTS games can be used for training of strategic and tactical thinking, as well as teamwork aspects. Moreover, due to real-time gameplay, time pressure can be used to assess how well players react in stressful situations. Examples are the *Command & Conquer series, Company of Heroes, or StarCraft*.

*Massively Multiplayer Online Roleplaying games* (MMORPGs) are games in which players play a fictional character in a fantasy world. An important feature of MMORPGs is that usually thousands of players experience the game within one instance (i.e., world). Hence, this type of game heavily relies on player interaction. Although often major parts of a game are in so-called player versus environment (PvE) mode where the player mainly interacts with the game environment, another major part is player versus player (PvP), where players play against other players. Also, even the PvE parts of a game are often played in groups of players, as it is easier to overcome difficult obstacles and enemies in a team. Hence, it can be assumed that MMORPGs heavily rely on player interaction and team play, and this is what existing MMORPGs are typically used for in a serious games context. Delwiche (2006) performed learning units of an undergraduate communication course using the MMORPG *Everquest* and the sandbox game *Second Life*. Childress and Braswell (2006) investigate the use of MMORPGs to foster communication and interaction and to facilitate cooperative learning. Steinkuehler (2004) addresses social aspects of learning of learning with and within MMORPGs. However, it should be noted that due to the enormous game development effort and the costs of maintaining an MMORPG infrastructure, it can hardly be recommended to create a serious MMORPG from scratch. Rather, it stands to reason to use existing MMORPGs or available modifications of those for serious game scenarios. Examples for this are described by Childress and Braswell (2006) and Herz (2001). If the modding tools are powerful enough, it might well be possible to include serious content in a mod, e.g., a historically plausible, playable epoch of a historical setting.

*Simulation games* describe a genre of games in which the focus is on illustrating a complex system, situation, or mechanism as realistically as possible by simulating it. In most traditional simulation games, this leads to insights into the complex interrelationships and interdependencies between different parameters of a system—while playfully testing the system and experiencing how the change of parameters influences it. This mechanism perfectly fits into a serious game context to demonstrate difficult systems or mechanisms, and lets players experience them in a playful environment without the consequences of failure. Examples for this are *Sid Meier's Civilization, Sim City,* and *TechForce* (see Fig. 8.5).

*Adventure games* are games which focus on a strong story line. Usually, gameplay is limited to experiencing a story and solving puzzles and riddles along the way. Often, player decisions decide the future course of the narration. The oldest adventure games used only text to set the scene and tell the story, giving players limited decision options. Later, adventures were typically 2D games with a static background image, limited interaction possibilities (usually based on an inventory system and combining and using items), and choices for each scene.

**Fig. 8.5** Screenshot of the serious game *TechForce*

Prominent examples are *Monkey Island* or *Maniac Mansion*. In recent years, 3D technology is used to increase immersion, but the core concept is still the same. Hence, adventure games can be used to wrap serious game content in a story to be interactively experienced by the players with a rather limited technical effort. It should be mentioned that most adventure games are single-player games, although there are some new multiplayer adventures (Lester 2013; Reuter et al. 2012).

Browser games emerged during the last decade. Although basically all game genres exist in the form of browser games, one specific type of games emerged from the use of browsers as the technical platform: *Social network games* (Casual Connect Research 2012). As no installation on the client machine (typically a PC or a smartphone) is necessary, casual gamers can easily be implemented because the technical hurdle is low. Browser games emerged with a huge community of active users. *FarmVille* from Zynga, to name an example, gained over 80 million players in 2010.[1] The rise and fall (server shutdown) of several such games, like *SimCity Social* or *Sim Social*, underline the challenge from a business model perspective: The games are offered for free, using the freemium revenue model (Runge et al. 2014). This means that the game itself is available for free, but players can be premium items, abilities, bonuses, etc., which give them an advantage. Usually, those advantages can also be gained by investing time in the game, but often there are bonuses that are exclusively available for purchase. Without a huge user base, operation of the central game servers is not profitable. As serious games can be considered more as niche products, rather than addressing a very large target group, such a revenue model seems to be impractical.

With the potential of social network games for educational purposes in mind, the design of a serious game could consider the following characteristics to be utilized to increase knowledge exchange among playing peers (Konert 2014a):

[1] http://mashable.com/2010/02/20/farmville-80-million-users.

- *Asynchronous play*: Multiplayer games are designed for social media-based interactions. Thus, players exchange items or manipulate the game environment, but do not have to be online at the same time. Everyone can play at her own pace and intensity without being dependent on other players.
- *Casual multiplayer*: As a virtual third place providing meaningful experiences, the game provides a multiplayer atmosphere with awareness of other players' activities (e.g., seeing their playground or avatars), but allows a rather independent single-player game play.
- *Competition*: Competition is only comparative by provided leaderboards or achievements; however, players cannot directly influence the game of other players. A "save private playing area" feature exists, in this state, the game cannot be damaged by other players (e.g., while the player is offline). Cooperative interactions allow for faster game progress, stimulating players to provide favors to others.
- *Beneficial social media interaction*: The three characteristics above are supported by an integration of social media interactions among players. These interactions can be categorized in four groups: Posting (new items, content), sharing (existing items or content with other players), discussing (opinions, decision making), and networking (neighborhoods, friendships, private networks). Some games use the network structure of existing online social networks such as Facebook, Twitter, or others for this purpose.

Thus, "a serious game satisfying all criteria mandatory for a social game" is called a *social serious game* (Konert 2014b).

The social aspects of a game can be such a strong motivational factor that game play is not the major reason for playing (Wohn et al. 2011). For further aspects see as well Sect. 8.4.7 on social issues in multiplayer game design.

### 8.2.3 Multiplayer Interaction

We now take a closer look at the interaction between players in a multiplayer scenario. Basically, players can play against other players (competitive), either with other players (cooperative, collaborative) or in a mixture of both (e.g., teams of players playing against each other). Each of these types has special features that can be utilized in a serious context.

**Competitive**. This type of gameplay is based on players in competition with each other to win the game. This competition can be direct, i.e., when players fight each other, or indirect, i.e., when players compete only via points they win, i.e., on a high score list.

In a direct competition, other players are considered opponents. Therefore, usually victory for one player means defeat for the opposing player. This results in the players' strategy to be directed towards defeating the opposing player(s). This means that a player or a team needs to play the game better than the opposing player or team. Here, "better" refers to gameplay in two dimensions—mechanical skills and knowledge about the game. An example for the first is the ability to quickly aim and shoot in an FPS, whereas an example for the latter is the knowledge of which weapon to use in which situation, e.g., regarding distance. The motivation to defeat the opponent hence can be seen as the driving force for a player to improve in both of those dimensions. In a serious context, this can be used if the characterizing goal can be integrated into the gameplay in a way such that the game's relevant (mechanical) skills and game knowledge conform with the characterizing goal.

Apart from that, there are various features that can be used to improve competition, like the already mentioned highscore list or in-game achievements. Both of these are even more effective if they can be combined with a player's social environment, i.e., friends. Using social networks in games enables game designers to reinforce competition by showing achievements and highscores to the friends of a player, thus challenging them to improve in the game. Examples for this method are friend lists in Steam or UPlay, which are used in games like *Farcry 3* to show when a player outperformed another player on his/her friend list.

**Cooperative**. In cooperative games, the gameplay is designed in a way such that players play in teams, i.e., they win or lose together. Hence, in cooperative games, the motivation is based on social dependency. Players can perceive a feeling of success by good team play, which again is based on good communication and common strategic planning. During the last two decades, this game mode was often included in games as a coop mode for the single player campaign, in which two or more players could play the single player campaign together, with limited or no changes to the game itself. This game mode was often criticized for a lack of game depth, as players were often merely playing next to each other instead of with each other.

However, cooperative gaming also takes place when players play in a real team with each other. Dillenbourg (1999) defines cooperation as follows: "In cooperation, partners split the work, solve sub-tasks individually and then assemble the partial results into the final output." In contrast, Roschelle and Teasley (1995) define collaboration as "a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem." Hence, when players are not mutually exchangeable and depend on each other (e.g., by filling different roles or by having resources to which others do not have access), gameplay is clearly collaborative.

**Collaborative**. In collaborative gaming, players do not merely play next to each other, but gameplay is based on those players to complement (the skills, knowledge, abilities, or resources of each other. There is an extensive review on how collaborative games work by Zagal et al. (2006). They show elements which are critical for collaborative games to work and pitfalls that should be avoided. The key points are:

- *Lesson 1*: "To highlight problems of competitiveness, a collaborative game should introduce a tension between perceived individual utility and team utility."

- *Lesson 2*: “To further highlight problems of competitiveness, individual players should be allowed to make decisions and take actions without the consent of the team.”
- *Lesson 3*: “Players must be able to trace payoffs back to their decisions.”
- *Lesson 4*: “To encourage team members to make selfless decisions, a collaborative game should bestow different abilities or responsibilities upon the players.”
- *Pitfall 1*: “To avoid the game degenerating into one player making the decisions for the team, collaborative games have to provide a sufficient rationale for collaboration.”
- *Pitfall 2*: “For a game to be engaging, players need to care about the outcome, and that outcome should have a satisfying result.”
- *Pitfall 3*: “For a collaborative game to be enjoyable multiple times, the experience needs to be different each time, and the presented challenge needs to evolve.”

Interaction between players in multiplayer games is mainly categorized as competitive, cooperative, or collaborative. In competitive games, players (or teams) play against each other; in cooperative games they build teams, and either the whole team wins or loses. In collaborative games, players are usually depending on other players (who may or may not build a common team) and need to help each other, i.e., collaborate in order to advance in the game. There are also mixed forms of these three categories.

Collaborative games, as they are heavily based on interaction between the players—focusing on teamwork, coordination, and supplementing each other—and are are well suited as serious games to teach, train, or assess exactly those social skills. However, assessment of teamwork and quality of teamwork is a rather complex task still being researched.

The concept of collaborative gaming is closely related to the concept of collaborative learning. Hence, this type of games is well suited for game-based collaborative learning in multiplayer (serious) games.

## 8.3 Collaborative Learning in Multiplayer Serious Games

In the literature, different definitions for the term *collaborative learning* can be found.

A different definition as the one of Roschelle and Teasley (1995) is provided by Thomson et al. (2009): “Collaboration is a multidimensional, variable construct composed of five key dimensions, two of which are structural in nature (governance and administration), two of which are social capital dimensions (mutuality and norms), and one of which involves agency (organizational autonomy)."

### 8.3.1 Collaborative Learning

Using those definitions of collaboration, the concept of collaborative learning will be elucidated next. Dillenbourg defined collaborative learning as "a situation in which two or more people learn or attempt to learn something together." This definition for itself is rather weak, as the term "together" does not specify what is special about the collaboration when learning. Therefore, Dillenbourg (1999) further states that it is necessary to trigger various specific learning mechanisms in order for learning to happen. Those refer to individual activities, but also to the interaction activities between the learning partners, such as explanation or disagreement. Those activities again are meant to trigger different cognitive mechanisms. However, it cannot be guaranteed that those interactions occur. Therefore, Dillenbourg also specifies four categories of methods, which aim to increase the probability of the interactions to occur in collaborative learning scenarios to:

- setup initial conditions (e.g., group size and composition)
- over-specify the collaboration contract with a scenario based on roles (e.g., reciprocal teaching)
- scaffold productive interactions by encompassing interaction rules in the medium (e.g., provide semi-structured interfaces)
- monitor and regulate interactions (e.g., teacher as facilitator, providing hints, redirecting group work)

> Collaborative learning is a situation in which two or more people learn, or attempt to learn, something together with various specific learning mechanisms.

An important aspect for the success of collaborative learning is both group size and composition of the group of learners. When forming learning groups for knowledge exchange, a variety of criteria need to be taken into account, including personality traits and level of proficiency. Moreover, some of these criteria need to be matched homogeneously (all members of a group are as similar as possible, e.g., in age), and other citeria need to be matched heterogeneously (members of the group are different and amend each other, e.g., in prior knowledge of topics). Moreover, the relevance of criteria and which of them need to be similar (homogeneous) and different (heterogeneous) within the group, depends on learning targets and the learning scenario (Konert 2014a). Learning group formation is therefore an active research area in the interdisciplinary field of technology-enhanced learning (TEL) (Inaba et al. 2000; Cavanaugh and Ellis 2004; Gogoulou et al. 2007; Ounnas et al. 2008; Paredes et al. 2010; Konert et al. 2014).

Moreover, various circumstances need to be met according to Johnson and Johnson (1999) in order for cooperation[2] to happen in collaborative learning scenarios. Those are:

- *Positive interdependence*: knowing to be linked with other group members in a way so that one cannot succeed alone. Positive interdependence results from mutual goals. In this context, interdependence includes resource, role and task interdependence. There is evidence about the effects of positive interdependence in collaborative learning scenarios as summarized by Johnson and Johnson (2009), e.g., when players depend on other players due to their role (i.e., a player needs another player's help because only that player has a certain resource).
- *Individual accountability and personal responsibility*: individual assessment of each group member's performance, communicated to both the group and the individual. "Individual accountability exists when the performance of each individual member is assessed and the results are given back to all group members to compare against a standard of performance" (Johnson and Johnson 1999).
- *Promotive interaction*: Promoting each other's success by e.g., helping, encouraging and praising. Promotive interaction occurs when group members encourage each other, help, or facilitate each other's efforts towards the group goal.
- *Appropriate use of social skill*: Interpersonal and small group skills are vital for the success of a cooperative effort. Appropriate use of social skills means that group members need to possess and be able to use various soft skills like communication, supporting each other, or being able to resolve conflicts.
- *Group processing*: Group members discuss their progress and work relationships together. Group processing is the act of reflecting on the group members' actions as individuals and as a group in order to evaluate their effort (Dillenbourg 1999).

A vital role in many collaborative learning scenarios is taken by the instructor (e.g., teacher, trainer) who has various important roles before, during, and after a collaborative learning session. The instructor usually has tasks in preparation of the collaborative learning session, like selecting learning goals, setting up motivation strategies, planning the learning scenario, activating attention, or reactivating prior knowledge. Furthermore, the instructor performs important tasks during the collaborative learning session, such as coaching or moderating, observing the learners and the learning process, and helping or redirecting. Finally, the instructor guides through the process of concluding and evaluating the results, and he/she performs a post-session assessment.

[2]Cooperation is used as a synonym for collaboration in the work of Johnson and Johnson.

The role of the instructor imposes a critical challenge for digital collaborative learning scenarios, as it is not trivial to enable the instructor to perform all those tasks appropriately in a digital learning environment. However, the use of digital learning or gaming technology also includes new chances for preparation, control, and evaluation and assessment of the collaborative learning scenario.

### 8.3.2 Computer-Supported Collaborative Learning

Computer-supported collaborative learning (CSCL) is the transfer of the collaborative learning paradigm to digital media, in most cases the computer. In the early years of CSCL, the "primary form of collaboration support is for the computer […] to provide a medium of communication" technology (Stahl et al. 2006). Hence, mainly Wikis, forums, discussion boards, newsgroups, chat rooms, instant messaging tools, video messaging, or email were used (Larusson and Alterman 2009). Later, more elaborate tools for CSCL were designed. Their fields of application are more focused on coordination, cooperation in groups, and cooperative learning rooms (especially virtual learning rooms) (Haake et al. 2004). Other collaborative learning tools and environments focus on group formation (Haake et al. 2004; Konert et al. 2014), collaborative document management, discussion groups, distributed classrooms (Konert et al. 2012), or virtual classrooms (Westera and Wagemans 2007; Denny et al. 2008). Whereas early virtual learning rooms were CSCL applications specifically designed for CSCL—often integrating a chat system and a shared screen—later versions used existing virtual worlds like *Second Life* or MMORPG worlds (Eustace et al. 2004). Moreover, there are platforms for knowledge exchange, collaborative knowledge access, student monitoring, or team-based learning.

### 8.3.3 Game-Based Collaborative Learning

Combining the collaborative learning paradigm with the advantages of computer technology and gaming principles and mechanisms appears to be a promising new way of creating game-based collaborative learning scenarios. If the mechanisms proposed by Johnson and Johnson and the requirements postulated by Dillenbourg can be incorporated in a multiplayer game design, digital game-based applications can be created—with the benefits of a motivating, fun environment and the assessment and evaluation tools coming from computer technology. On top of that, if the game incorporates the instructor in an appropriate way, it becomes possible to improve the instructor's work in a collaborative learning scenario. The mechanisms for collaborative fun gaming are very well suited for a game design, which fosters collaborative learning as the characterizing goal. They provide design guidelines to split the work among players/learners, to develop heterogeneous resources, to assign distinct tasks and abilities within the learning context, and to supply methods to foster communication and teamwork.

**Fig. 8.6** Screenshot of Escape From Wilson Island of players carrying a palm tree together

Hence, in recent years, the first CSCL serious games have been designed and implemented. They incorporate CSCL principles and combine them with serious games mechanics, resulting in multiplayer serious games for collaborative learning (Zea et al. 2009). Hämäläinen (2011) describes an approach of a collaborative game for vocational learning, focusing on design elements essential for collaboration. Reuter et al. (2012) describe an approach for designing and authoring multiplayer adventures for collaborative learning, deriving concepts for puzzle design in multiplayer games. Other examples are the collaborative multiplayer serious games *Escape From Wilson Island* (Wendel et al. 2012) (see Fig. 8.6), and the serious game for teamwork workshops *TeamUp* (TeamUp 2015).

Yet, the lack of game-based collaborative learning applications in the market suggests that there are still obstacles and challenges to overcome. The design of teamwork, a component which is central to collaborative learning, is still not very well understood. Quantifying the amount and quality of teamwork and collaboration is challenging. In the literature, different performance measures are proposed. Bowers et al. (1992) use coordination as a measure for teamwork. They created a list of coordination behaviors based on seven behavioral dimensions. Those are: Communication, situational awareness, leadership, assertiveness, decision making, mission analysis, and adaptability. They are used to assess the frequency and quality of coordination. Paris et al. (2000) created a taxonomy of variables with an influence on team performance, providing the relevant factors with examples and applicable interventions to train those factors. They are grouped into contextual factors (e.g., culture, education system and information system), structural factors (e.g., physical environment, organizational arrangements and technological systems), team design factors (e.g., task interdependence, team size and composition and leadership), process factors (e.g., performance norms, communication, team interactions and team spirit), and contingency factors (e.g., team mission, resource availability, rules of operation, managing and decision-making). For each of those factors, they define a set of applicable interventions:

- Contextual factors: team selection, task design, training
- Structural factors: team design, training
- Team design factors: team selection, task design, training
- Process factors: team selection, task design, training
- Contingency factors: task design, training.

In addition to such parameters and factors, other metrics have also been proposed. A cooperative performance metric concept is described by El-Nasr et al. (2010). It contains the following six metrics (measuring positive and negative aspects) to measure teamwork, all relying on observation, with game sessions being recorded, observed, analyzed, and annotated:

- laughter or excitement together (pos.)
- worked out strategies (pos.)
- helping (pos.)
- global strategies (pos.)
- waited for each other (pos.)
- got in the way of each other (neg.)

Shapiro et al. (2008) provide an overview over metrics for team performance for simulation-based training in the domain of healthcare. They distinguish four types of metrics: Event-based measurements, behavioral observation scales, behaviorally anchored rating scales, and self-report measures. One of their main results is the fact that "there is no standard team performance metric or set of metrics [...] across the healthcare disciplines."

Another problem lies in the social component of multiplayer games and collaborative learning scenarios. As those scenarios involve a group of players/learners—even in a small group—the problem of *free riding* exists. Technical possibilities such as event logging, observation, etc. allow to counter this problem. Generally, it is assumed that learners and players feel that their contributions are more crucial to the progress of the team in smaller groups than in larger groups (Kidwell and Bennett 1993; Hindriks and Pancs 2002). Considering an optimal group size, Hare (1981) suggests a size of five, and states that for larger groups, individual group members might have fewer opportunities to contribute to the progress of the team.

Furthermore, the role of the instructor, while undoubtedly crucial to the collaborative learning process, presents a challenge for game design. Usually, this role does not exist in other games, except perhaps in role-playing games. The concept of role-playing games has been ported to computer and video games, yet without the role of the so-called Game Master: His/her role is similar to the role of an instructor in collaborative learning scenarios. Hence, in this context there exists research on how to utilize the concept of a Game Master in a digital game (Tychsen et al. 2005; Tychsen 2008; Wendel et al. 2012).

Nevertheless, there is still a lack of concepts on how to generally include instructors in multiplayer collaborative games such that they are able to perform their tasks as well as possible, supported by modern technology. This might be a major obstacle for using collaborative multiplayer games in training or teaching. In general, reluctance can be observed among many teachers in many European countries to use game technology—or even just computer technology in general—in class. This reluctance results from two main problems: Lack of familiarity with the medium and fear of loss of control when using a game technology without a Game Master.

## 8.4 Multiplayer Game Design

Generally, the same game design guidelines, hints, and pitfalls valid for single-player games also apply to multiplayer games. Those were already discussed in the earlier chapters of this book. The focus here will be on those features that are specific for multiplayer games.

When designing a serious game, one of the first steps is to define the target group and the characteristic goal of the game. In multiplayer games, it additionally needs to be decided how many players are supposed to play the game—whether they participate simultaneously or in an asynchronous way, if they play together in teams, against each other in a competitive way, or a combination of the two. In this context, it is relevant whether the game world is persistent or if games are played in (short) sessions. In competitive scenarios, matchmaking—matching opponents as fair as possible—is an important aspect. Moreover, the speed and flow of the game need to be taken into account. Further, it needs to be considered what influence communication, or the lack of it, might have on the gameplay. Social issues like grieving, mobbing, or toxic behavior of the players also needs to be considered, especially in a classroom environment. Finally, it needs to be considered to what extent the game will depend on hardware and network infrastructure in terms of latency (see before, not in focus here). Hence, the following characteristics have an impact on the game design:

- Number of players
- Persistency
- Matchmaking
- Competitive versus Collaborative
- Game speed and flow
- Influence of communication on gameplay
- Social issues (Grieving, Mobbing, Toxic behavior)

### 8.4.1 Number of Players

As discussed in Sect. 8.2, different multiplayer game genres are inherently appropriate for different numbers of players. Whereas an FPS is well suited for many players but possibly rather boring if played by only two players, the opposite is valid for strategy games—both round-based or real-time simulation (RTS) games. Round-based games tend to become boring due to long waiting times with an increasing number of players, and RTS games are limited in the number of players due to issues of overview and balancing. Hence, the number of desired players impacts the suitability of genres for the serious game to be designed.

### 8.4.2 Persistence

Another characteristic to be considered is persistence. Depending on the game type, there might be a persistent game world, or the game only persists during game sessions. The former is an example for most of the big roleplaying game worlds today, like *WoW, EverQuest*, etc. Those worlds exist continuously, independent of a player being in the game or not. Examples for the latter are FPS, strategy games, or simulations. In those genres, the games have a clearly defined start (when all players have joined the game) and end (usually when a winner is determined or the session is aborted). In most such games, the session continues or is paused if a player leaves the game (due to connection problems, etc.). If no pause is possible, the game continues without the player until the end condition (victory/loss) is reached. However, there is no persistent game world whatsoever between game sessions. A persistent world is always present and accessible. Hence, players can join the game whenever they wish, and players spending more time in the game world might have an advantage compared to players just joining. This needs to be considered in the game design. For example, in social network games, persistence is a prerequisite for the characteristics of asynchronous play and casual multiplayer access. For a non-persistent game, it needs to be considered that it usually can only be played when the required number of players is available.

### 8.4.3 Matchmaking

For competitive games, fairness is a central issue. If games are unfair or players with unequal skill are matched against each other, this might have a serious impact on the game experience and fun.

Hence, *matchmaking*—the automated process that matches a player to and against other players in games—is used in most of today's competitive games. This term should not be confused with the term matchmaking in computer science which describes the marriage problem. The general idea of matchmaking in games is to represent a player's relevant skill(s) for a game by a (set of) number(s) and match players according to those.

The most prominent matchmaking concept is the ELO concept, which originally was designed by Elo (1978) to match chess players according to their skill level. In the Elo system, each player has a skill value R assigned to him/her. Comparing two skill values $R_A$ and $R_B$ of players A and B gives an indication of what the probabilities for each of those players is to win the game. The following formula gives the win probability $E_A$ for player A:

$$E_A = \frac{1}{1 + 10^{(R_B - R_A)/400}}$$

After a game, the Elo value of both players is updated according to the following formula:

$$R'_A = R_A + k \cdot (S_A - E_A)$$

Here, $R'_A$ is the new value for player A, $R_A$ is the old value for player A, $S_A$ is the result of the game (1 for a win, 0.5 for a draw, 0 for a loss), and $E_A$ is the win probability for player a. *k* is a weighting constant that usually changes according to the number of games played—such that the Elo value changes more heavily for new players, and less heavily for players after many games.

The ELO concept has since been extended to various competitive games (e.g., *League of Legends*, *DotA2*, etc.). However, the specific enhancements are not publicly available.

Elo was originally designed for a 1:1 setting, and this is where it works best. Elo has weaknesses in team scenarios, especially when a team does not consist of a fixed set of players. If teams are built in an ad hoc fashion, which is often the case in team-based multiplayer games as new players often join alone, such games need mechanisms to form teams with the available players in a fair matchup.

The Glicko system (Glickman 1995) uses a Gaussian approach where skills are assumed to lie within a variance $\sigma^2$ around mean value $\mu$. Hence, the basic idea is that the initial estimated skill value lies within an interval that can be narrowed with every additional game played, thus making the estimation more and more accurate.

In contrast to the Elo system, Glicko can make an assumption of how accurate the current rating of a player is by using the variance, which should be smaller for players with many games and larger for new players. Moreover, it can measure consistency in player performance.

The TrueSkill model, developed by Microsoft Research for the Xbox, matchmaking system uses a Bayesian approach to estimate the skill of a player in a team (Herbrich et al. 2006). A factor graph is used to determine a team's strength based on its players' skills.

All of those models, however, do not consider different roles. Yet, in many team-based multiplayer games, different players usually take different roles, like e.g., damage dealer, healer, tank, etc. The success of a team depends on:

- a good composition, i.e., a team of five damage dealers might be inferior to a team with a well-tuned ratio of damage dealers, tanks, and healers)
- the players' skill in the role they are playing

The second condition can be problematic as the players' skill for each position can vary. Hence, players can be stronger on some positions and weaker on others. This can be compared to the different *roles*, i.e., *positions* in soccer, like striker, defense player, or goalkeeper. Usually, a good striker is not necessary equally good when he needs to play as goalkeeper. This problem can be circumvented if the matchmaking can make sure that each player plays in his/her preferred position, which is usually the case in teams with fixed members. However, in multiplayer games where players join the game alone and then get assigned to a team, it is very likely that players need to play a role which they are not good at.

The TrueSkill-ext rating by Zhang et al. (2010) is an extended version of TrueSkill. It uses a multivariate Gaussian model, where an $m$-dimensional vector is used describing $m$ different contexts (one for each role) of a player. It should be mentioned that this only works if role selection is made before the team is assembled.

Besides fairness, in learning games, maximizing learning outcomes for each player is a major aspect. Thus, based on insights from learning theory, the learning group formation algorithms that emerged not only take into account skill level, but also how well team members complement each other and harmonize in their group roles, personality traits, learning style preferences, etc.

As analyzed by Konert (2014a), from an algorithmic perspective two major groups of approaches exist: Semantic matchmakers and analytic optimizer algorithms. The former have their strength in respecting manifold boundary conditions while matching learners based on an ontology of their knowledge domain; see also (Inaba et al. 2000) or (Ounnas et al. 2008). A major disadvantage is the need for a formalized ontology of the knowledge domain and/or the boundary conditions if a logic solver is used.

Analytic optimizers, on the contrary, have no detailed information about the interdependency of the manifold criteria to match. They operate on vector representations and use a limited set of boundary conditions, such as the maximum group size or the minimum group formation quality, based on a suitable metric for quality calculation, often called the fitness function. Paredes et al. (2010) match learners homogeneously by cluster analysis, but this appears to be limited in case learners are heterogeneous in their skills, e.g., to complement each other in the field of expertise and learn from each other the most. For this case, Cavanaugh and Ellis (2004) use an iterative approach to build learning groups for cooperative tasks. Gogoulou et al. (2007) provide several algorithms for the homogeneous, heterogeneous, and the mixed approach when some criteria have to be homogeneously matched, while others should be heterogeneous among the group members. Additionally, they have identified visual feedback for teachers (or instructors) as a valuable component in order to allow manual group adjustment and feedback about formed group quality. Based on the analysis of these approaches, in (Konert et al. 2014) the GroupAL algorithm is proposed that allows to use weighted homogeneous and heterogeneous criteria, while taking into account that all formed groups should be rather similar in their combined group quality. The key idea behind the GroupAL algorithm is to use the distance in criteria vectors $K^1, K^2$ between all possible pairs of members. The smaller the distance between two vectors is, the more similar two members are. For each criterion a weight is considered. A vector $W$ represents the weights for all the criteria. For homogeneous criteria $(K_{het})$ this vector distance should be minimal, while for heterogeneous criteria $(K_{hom})$ the distance needs to be maximized. This is considered in the following equation for the so called Pair Performance Index which reached its maximum value, if the *homSum* is minimized and the *hetSum* is maximized):

$$PPI\left(K^1, K^2, W\right) = hetSum\left(K^1_{het}, K^2_{het}, W\right) - homSum\left(K^1_{hom}, K^2_{hom}, W\right)$$

In following steps, $PPI$ is normalized to a value space in the interval $[0, 1]$, and a group performance index is calculated using the normalized standard deviation of $PPI$. To find the best combination of members for a group (i.e., maximize PPI over all groups) is a combinatory problem, which can be solved by optimization algorithms using $PPI$ as the metric to judge how good is a new build group. If the result not good enough, new combinations are built and kept—if the resulting $PPI$ values for all pairs of group members are better than before. To keep the algorithmic runtime performance manageable, GroupAL (like other algorithmic optimization approaches) starts with pivot elements as first group members and then searches for the next best candidate to add as long as not all groups are filled (or all participants have a group). Such optimization approaches generate reasonable results in scenarios with up to a few thousand learners to match (Konert et al. 2014). Suitable algorithmic solutions for larger scenarios are subject to ongoing research.

### 8.4.4 Competitive Versus Collaborative Gameplay

Another aspect impacting game design is the question of whether the game will be played competitively, cooperatively, or collaboratively. Special game design decisions need to be made to enable cooperative or collaborative gameplay. Especially for collaborative gameplay, design guidelines for collaborative gaming by Zagal et al., as well as the collaboration-related design guidelines by Dillenbourg and by Johnson and Johnson (see Sect. 8.3.1), need to be considered; see Sect. 8.2.3.

For competitive gameplay, fairness (matchmaking) needs to be considered for pairs of adversaries. Moreover, incentives like leaderboards, high scores, etc. can be used to motivate players.

For both competitive and collaborative games, it should be considered if and how different roles can be included into the game design. For competitive games, this might be a way to create team-based competitive games. For collaborative games, this might help to implement the advised guidelines for collaborative play, for example by providing heterogeneous resources.

A mixture of both, using the concept of *coopetition*, can be achieved if casual multiplayer concepts are implemented, as in social serious games (see Sect. 8.2.2).

### 8.4.5 Game Speed and Flow

Game speed and flow should be considered as early as possible in the design phase. Depending on the characterizing goal, the best genres can be found based on these criteria. Yet, for each genre, there are various kinds of games with a different gameplay, which impact how the serious game will work. If, for example, it was decided that a strategy game is the best choice, it needs to be decided if the game is going to be turn-based, real-time, or have a variable speed, if it should be possible to pause the game, etc. Those decisions might be influential regarding the learning content. For example, if it is required that players reflect on the learning content while playing, a slower-paced game (e.g., turn-based or with pausing) might be more appropriate than a real-time simulation.

### 8.4.6 Communication Between Players

Communication is another core element of multiplayer games that greatly impacts how the game is played. There are various ways of enabling communication between the players. They can be classified into three main categories:

1. in-game signs
2. chat
3. voice communication

*In-game signs* are a method of communication which is not based on text or speech; instead, it uses available mechanisms of the game to draw another player's attention to a relevant event. Examples are so-called pings, where a player marks an object or location in the game world (often on a map) to tell another player that something important is happening there. This is often used in team-based strategy games. Another example is avatar-based gestures, which are common in role-playing games where players are represented by an avatar. Those gestures can be used to mediate affections, feelings, or expressions without the use of language.

*Chat* is probably the most common way to communicate in a game. By chat, we mean digital chat tools for the exchange of short messages. While they are very simple and powerful, they require that players speak a common language and are able to express themselves in written form, possibly under time pressure. Hence, chat might not be the right communication solution in multiplayer games, depending on the target group (e.g., too young or international players) or the game type (in RTS games there is often not enough time to type complex phrases in a chat tool). Therefore, a slightly different and simpler way of chat-based communication is to use predefined commands such as *help*, *well done*, *come here*, or *do X* with just one mouse click. While this is more restrictive than a regular chat, it is quickly accessible, and it limits the misuse of a chat for off-topic discussions.

*Voice-based communication* is the third alternative. Here, players can communicate simply by talking to each other. Trivially, this is possible if all players are together in one room. If this is not feasible, voice communication tools like Skype can be used. Today, many such tools are available that are specialized in team-based communication for online games, like TeamSpeak, Mumble, RaidCall, or Curse Voice. Moreover, many online games have built-in voice communication. While due to its wide availability, voice communication is not a technical challenge for a game designer; however, it needs to be considered that voice communication is available to the players whether intended by the game designer or not. So, unless it cannot be assured that players do not use voice communication (like in a classroom setting), one should assume that players will use voice communication. This might impact various design decisions. For example, in a shooter game, a player who was eliminated from the game (i.e., was killed) can still talk to his/her teammates via a third party voice communication tool and give valuable hints.

### 8.4.7 Social Issues: Toxic Behavior and Virtual Property

Apart from communication, other social issues can have an influence on a multi-player serious game.

In online games with persistence, there are usually players who are more experienced than other players. Those players have an advantage in game knowledge, and if gameplay is based on leveling up virtual characters, those players are probably more advanced in the game and hence more powerful than new players. Therefore, the game designer needs to think about problems of power imposition, namely using the fact that one player is stronger in order to negatively impact another player's game experience, e.g., repeatedly killing that player's character. There are various countermeasures, like so-called safe areas where player versus player combat is not possible, or mentoring systems where experienced players help new players. Apart from being more powerful, other forms of grieving (annoying other players on purpose) are verbal harassment, scamming (breaking promises), ninja looting (stealing loot from a player before that player can pick it up), leaving a game to prevent a loss, account sharing (sharing an account with other players to have advantages), multi accounting (having more than one account to boost the primary account), and many more. It needs to be considered to which extent this toxic behavior can occur in the serious game to be created.

There are some countermeasures against toxic behavior in existing online multiplayer games. Most of them provide their players with an option to report toxic players to administrators. They can judge if those players should get a penalty. In other games, this decision is given back to the player base for players who have been reported by several others too many times. The community then decides if those reports were justified, and if the player should be penalized. However, a study by Riot games (Lin 2013, 2014) showed that penalizing negative behavior alone is not sufficient to deal with toxic behavior in online multiplayer games. They suggested that positive reinforcement, in addition to the negative reinforcement, should be used. Hence, they gave players an option to honor fellow and opposing players for good teamwork and sportsmanlike behavior. They also showed the importance of visibility, i.e., that both the players themselves and other players can see if a player is positive.

Apart from this, virtual property is a problem the comes with state of the art online multiplayer games. In some of these games, players can own virtual property (e.g., a valuable magic sword). Usually, this is acquired by playing the game for a long time. However, as they usually can be traded between players, and players are willing to pay rather than spending a lot of time, those virtual items get a real monetary value. Until recently, virtual property has led to a lot of problems in gaming communities. On the one hand, virtual property is still considered a legal grey area as many legal institutions do not consider virtual property as legal property. For example, theft of virtual property is not covered by the law. Even real murders connected to virtual property were reported. This shows that game designers need to carefully consider if, and in which form, they include virtual property in their games.

On the other hand, virtual property can be a very powerful and beneficial aspect of game design, when players are empowered to create their own game elements. So called user-generated content allows players to personalize their game, be creative, and share their ideas with others. If used properly by game designers, user-generated content is a way to allow an endless amount of new content, quests, and tasks to be added to the game (e.g., new levels in Sony's *Little Big Planet,* or creatures in Electronic Arts' *Spore*). Especially for serious games with a limited budget, this seems to be an attractive option. Obviously, efficient quality control mechanisms have to be added to prevent content containing incorrect facts, low quality content, or illegal content to be spread via the game. From a didactic perspective, support for user-generated content allows for deep learning experiences as players not only solve predefined problems, but also ask questions create quests and provide proper new solutions. These abilities are part of the high-level problem-solving skills that are very suitable to be taught via games (Gee 2009).

## 8.5 Summary and Outlook

This chapter provided an overview of multiplayer serious games. Starting with an historical view on digital multiplayer games, we considered the development of multiplayer games and covered many facets of multiplayer gaming.

The chapter shows how multiplayer games can be classified in terms of game types, used techniques, genres, and interaction forms. This covers the use of various technologies like shared screen or split-screen, appropriateness of game genres for various serious gaming purposes, and which interaction form(s) can be used in a serious games context.

Further, this chapter covered the topic of collaborative learning, especially focusing on the relationship between collaborative gaming and collaborative learning. It is shown how the concepts and paradigms of collaborative learning can be naturally used in multiplayer games, and how they can be further utilized to improve collaborative learning in multiplayer games.

Finally, multiplayer game design issues were discussed, looking at the various dimensions of multiplayer gaming that impact the design process, and hence should be considered from the very beginning. Those are: Number of players, persistence of the game world, matchmaking, competitive versus collaborative gaming, game speed and flow, communication, social issues like toxic behavior, and user-generated content.

Check your understanding of this chapter by answering the following questions:

- Why were many of the oldest digital games multiplayer games?
- How are multiplayer games today different from multiplayer games in the 1970s and 80s?
- What forms of multiplayer games do you know about?
- What multiplayer genres do you know, and how are they appropriate for serious game purposes?
- What different kinds of communications do you know in multiplayer games?
- Why do multiplayer games offer great potential when it comes to collaborative learning?
- What collaborative learning concepts are used in multiplayer games, especially MMORPGs?
- What are important rules and pitfalls when designing collaborative multiplayer games?
- How do the number of players, game world persistence, or game speed and flow influence the design of multiplayer serious games?
- What is the role of matchmaking in multiplayer games? Why is this important for MMOGs? Why and under which circumstances might this be important when designing multiplayer serious games? Why is it even more complex to match players in serious games?
- What influence on the design of a multiplayer serious game does in-game communication have?
- Why are social issues relevant when designing multiplayer serious games, and what are current problems in MMOGs related to social aspects? Which counter-measures exist?

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Huizinga, J. (2014) *Homo Ludens: A Study of the Play-Element in Culture*. Martino Fine Books—*If not recommended in other chapters already, this book needs your full attention. It is not an educational book in a classical meaning, but a classical book about humans faible for playing, the socio-cultural integration of play and the meaning for each individual's development. As such, the book highlights the multiplayer aspect from a totally non-technical perspective, which leads to fresh insights for everyone with technical mindsets when designing multiplayer games*

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